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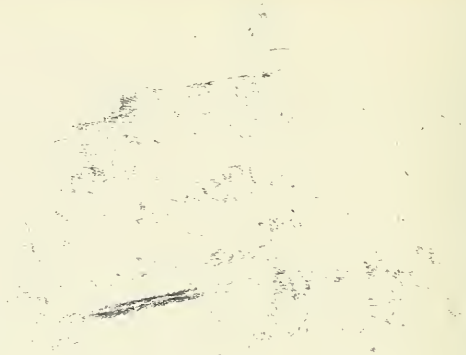

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Bulletin 544

AGRICULTURAL EXPERIMENT STATION
WEST VIRGINIA UNIVERSITY

BULLETIN 544

Science

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Flyash: New Hope for Strip Spoil?

Carl F. Engle and John P. Capp*

FLYASH is a waste product from burning coal at electric power generating stations. It is the lightweight ash that is electrically precipitated and mechanically removed to disposal dumps after it leaves the boilers. By 1970 the production of flyash in the United States is expected to exceed 30 million tons. West Virginia power companies are currently producing about two million tons yearly which, at an average cost of approximately 50 cents per ton for disposal, is costing them in excess of one million dollars. These figures are expected to increase sharply in the next several years in West Virginia with the completion of several large coal burning power stations. Aside from the cost of disposal of flyash, there is the aesthetic problem created by flyash dumps.

Markets for flyash include its use as a cement additive, and for making building bricks and lightweight building blocks, but only a small portion of

Mowing the "lawn" on a strip spoil treated with flyash. (All photos courtesy Bureau of Mines.)

*Engle is Agronomist; Capp is Chemical Research Engineer, U. S. Department of the Interior, Bureau of Mines, Morgantown Coal Research Center.

Figure 1. Spoil area before addition of flyash.

the flyash produced is utilized. A promising way of disposing of large tonnages of the material as a soil additive and conditioner in the reclamation of acid surface mined areas is being studied by the Agronomy and Genetics Department of West Virginia University, in cooperation with the U. S. Bureau of Mines, Morgantown.

A number of properties of flyash make it attractive as an additive and conditioner for reclaiming acid surface mined areas. These are large quantities, easily available, a high pH to neutralize acid soils, a higher content of some macro and most micro plant nutrients than many soils, better moisture retention than many soils, and a loosening effect when mixed with heavy textured soils. Table 1 shows some of the more common elements determined in flyash obtained from the Albright, West Virginia, station of the Monongahela Power Company. The percentages of the elements listed are about the same or somewhat higher than those found in many natural soils. Most flyash sources, however, contain very little phosphorus and generally are devoid of nitrogen. These elements must be added through fertilization if vegetation is to be established on flyash.

Greenhouse studies at West Virginia University as well as extensive field studies in England and Germany have shown that vegetation is most successfully established on highly alkaline flyash if mixed with acid materials such as peat and subsoil. Enough flyash must

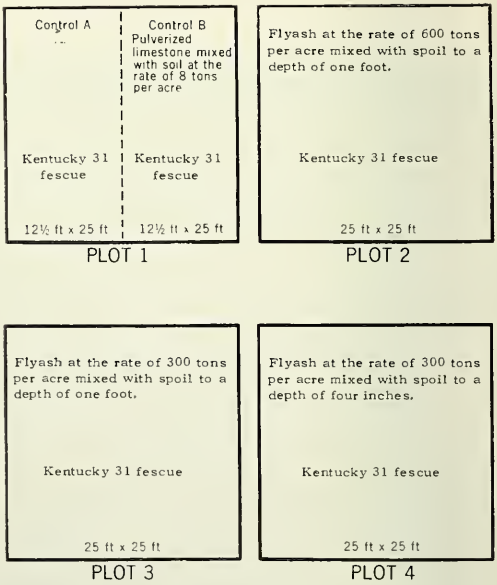

Control A
Kentucky 31 fescue
12½ ft x 25 ft
Control B
Pulverized limestone mixed with soil at the rate of 8 tons per acre
Kentucky 31 fescue
12½ ft x 25 ft
PLOT 1
Flyash at the rate of 600 tons per acre mixed with spoil to a depth of one foot.
Kentucky 31 fescue
25 ft x 25 ft
PLOT 2
Flyash at the rate of 300 tons per acre mixed with spoil to a depth of one foot.
Kentucky 31 fescue
25 ft x 25 ft
PLOT 3
Flyash at the rate of 300 tons per acre mixed with spoil to a depth of four inches.
Kentucky 31 fescue
25 ft x 25 ft
PLOT 4
Fertilizer (10-10-10 analysis) applied to all plots at rate of 1,000 pounds per acre.

Figure 2. Diagrom of test plots.

Figure 4. Plot 2. Flyash at the rate of 600 tons per acre mixed with spoil to a depth of one foot.

be added to the acid materials to produce an equilibrium pH between 5 and 7 in the mixture. This accomplishes the precipitation from solution of elements toxic to plant growth such as aluminum and manganese. These studies led to the decision to use flyash in a manner never before tested. A field experiment was established at an acid surface mine spoil area near Westover, West Virginia, to determine if a high rate of flyash application would neutralize the spoil acidity sufficiently for plant survival and growth. Initial physical and chemical properties at the site were: pH—3.5; nitrogen, phosphorus, potassium and organic matter—very low; cation exchange capacity (C.E.C.)—12 milliequivalents per 100 grams; clay, silt, and sand—21, 23, and 56 per cent, respectively. The spoils contained many coarse fragments, ranging in size from pebbles up to boulders weighing several hundred pounds. Figure 1 shows the spoil area before flyash was added.

Test plots were established during June and July of 1965 by plowing, removing large boulders, incorporating flyash as desired, firming a seedbed by dragging, and seeding with Kentucky 31 fescue, a perennial grass that provides good cover where the pH is above 4. Figure 2 is a diagram of the test plots showing the rates of application of flyash, lime, and fertilizer.

The growth of fescue was good on control plot 1-B following treatment with pulverized limestone at the rate of 8 tons per acre. Growth was better, however,

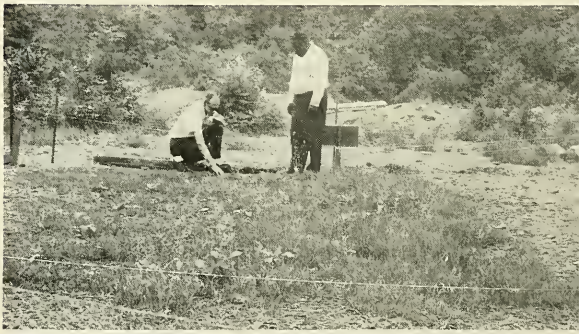


Figure 3. Control Plot 1-B. Pulverized limestone mixed with soil at the rate of 8 tons per acre.

on plot 2 which received 600 tons per acre of flyash mixed to 12 inches with the spoil. This was due mainly to a faster neutralization of spoil acidity. Figures 3 and 4 show the comparison. Growth was poor on plot 3 which received only 300 tons per acre of flyash mixed to a depth of one foot. On plot 4, where flyash was applied at the rate of 300 tons per acre and mixed with the surface four inches, growth was poor at first but later improved until it equaled the appearance of plot 2. Because of the poor growth on plot 3 more flyash was added to it and worked in with a rototiller in September 1965 to make the application

Figure 5. Excellent stand of fescue on Plot 3 after increasing flyash rate from 300 to 600 tons per acre.

rate equal to that of plot 2. Figure 5 shows the excellent stand of fescue on plot 3 after bringing the application rate up to 600 tons per acre.

The fescue on all plots survived the first winter and developed an excellent root system which served to stabilize the spoil-ash mixtures, checking erosion. Growth in the spring was good because of sufficient rainfall and nutrients. Yields taken in May 1966 compared favorably with average dry matter yields for West Virginia of 2.5 tons per acre. Dry weight yields for plots 1-B, 2, 3, and 4 were 2.5, 3.1, 1.7 and 1.9 tons per acre, respectively.

The pH of the flyash treated plots was raised from an initial value of 3.5 to 5.0-5.3. This pH range is being maintained and is the reason for the good growth of the fescue. At pH values above 5.0 very little aluminum and manganese, the principal toxic elements in spoil, are in solution. There is some question as to whether this favorable pH can be maintained or whether it will drop below 5.0 and the solution of toxic elements ultimately kill the vegetation. This question can be answered only with time. However, time appears to be on the side of the flyash. An optical examination of the flyash reveals that it is composed largely of glassy spheres, 0.02 to 2.0 mm in diameter, derived from shales that were in the coal. A large portion of the elements in the coal were fused upon combustion into these spheres. In a 600 ton per acre application of flyash of the composition shown in Table 1 over eight tons of liming material in the forms of elemental calcium and magnesium are being added. With many flyashes, double this amount could easily be added in a 600 ton per acre application. Much of this liming material is slowly released, because it is fused into glass spheres, and should neutralize the spoil for many years. The flyash will not have to do the job alone of making the spoil-flyash mixtures an adequate environment for plant growth. It will be helped by percolating water leaching out acid forming compounds from the spoil and by the accumulation of organic material which will promote biological activity and general improvement in the physical properties of the mixtures.

TABLE 1

Flyash Analysis

Element	Percentage	Pounds per 600 Ton Application
Calcium	1.00	12,000
Magnesium	0.36	4,320
Potassium	1.74	20,880
Phosphorus	0.132	1,584
Cobalt	0.005	60
Molybdenum	0.007	84
Boron	0.008	96
Manganese	0.021	252
Aluminum	14.10	169,200
Iron	9.94	119,280

Reclamation of surface mined areas with flyash would have a tremendous impact on the beautification of the Appalachian region. Currently in the Appalachian region there are over 460,000 acres of surface mined land, an area almost as big as Great Smoky Mountains National Park. We are adding to this area at the rate of about 14,000 acres per year by the surface mining of coal. Flyash produced by electric utilities in this same region approaches six million tons per year which is enough to reclaim 10,000 acres per year with an application rate of 600 tons per acre.

Reclamation with flyash would provide a way for the landowner, surface mine operator, and power company to cooperate in waste disposal and land beautification to the benefit of all.

Effects of Breed, Season, and Stage of Lactation on Certain Constituents and Properties of Milk

S. J. WEESE, D. F. BUTCHER, and R. D. THOMAS

Weese is Assoc. Dairy Scientist; Butcher is Asst. Dairy Scientist; and Thomas is Asst. Animal Nutritionist.

THE ability of the dairy cow as a ruminant to convert roughage into nutritionally desirable human food is the basic reason for its place in the agricultural economy. In the past, this nutritional justification has emphasized the milkfat constituent. Consequently, extensive genetic studies have been carried out on the milkfat yield of cows in order to intelligently control its production through breeding methods. Today, however, increasing attention is being given to the nutritional attributes of the non-fat constituents, particularly protein; the knowledge to control the production of these constituents through breeding is lacking.

To obtain data for a study of the milk constituents, 24-hour composite samples from individual cows of the Ayrshire, Holstein, Jersey, and Guernsey herds of the West Virginia Agricultural Experiment Station were used for all analyses. The evening sample was obtained immediately after milking and was placed in cold storage. The morning sample was added to the previous evening sample to obtain the composite 24-hour sample. Samples were taken monthly for a period of 20 months from September 1963 to April 1965. Only cows with a complete lactation period of 240-305 days were included in the analysis.

The following constituents or properties were determined and methods employed for each were as follows: Milkfat—Babcock test; Solids-Not-Fat—Watson lactometer; Protein—Orange G Dye-Binding method; Freezing Point—Fiske cryoscope; Chloride—Fisher automatic titrimeter.

The fat, solids-not-fat (S.N.F.) and protein percentages were the constituents of main concern in this study. The freezing point and chloride percentages were included as additional information due to lack of available published information.

Results of Analyses

The Ayrshire and Holstein fat percentages were higher (Table 1) than usually given for the two breeds. The combined Guernsey-Jersey fat test averages were comparable to published reports. As shown in Figure 1, the average fat percentage of Ayrshire milk declined during the first four months of the lactation period, followed by a slight increase until the tenth month, which was slightly lower than the ninth month. The Holstein average fat percentage declined from the first to the third month of lactation, which was followed by an irregular increase to the tenth month of lactation. The Guernsey-Jersey fat percentages followed no definite pattern.

TABLE 1

Breed	No. of Sample	Fat (%)	Protein (%)	Freezing Point	Chloride (%)	S.N.F. (%)	T.S. (%)
Ayrshire ...	378	4.45	3.56	−0.542	.1011	8.88	13.36
*Guernsey and Jersey	126	5.12	3.95	−0.545	.0889	9.45	14.53
Holstein ...	279	4.35	3.34	−0.544	.0996	8.75	13.11

*The Guernsey and Jersey tests were combined due to the smaller number of samples for each breed.

The effect of season on the fat percentages are shown in Figure 2. In May the fat percentages were

Figure 1. Effect of stage of lactation on percentage of protein.

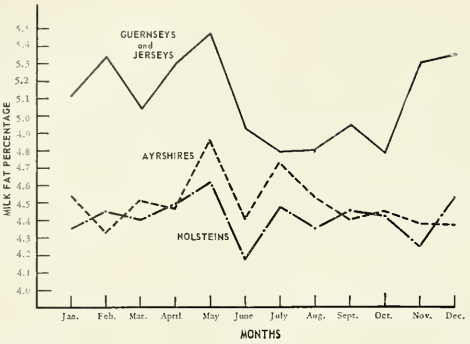


Figure 2. (Above) Effect of season on percentage of fat.

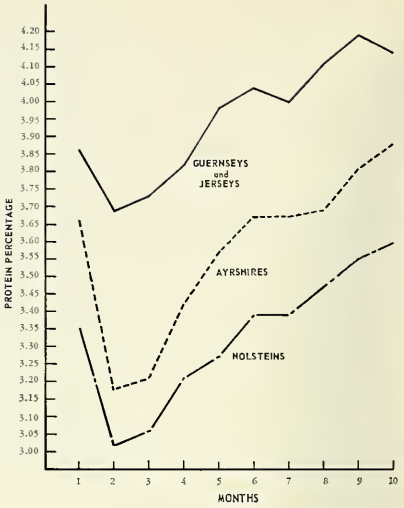


Figure 3. (Right) Effect of stage of lactation on percentage of protein.

high, followed by a sharp decrease for the June tests for all the breeds.

The protein content of the milk (Table 1) compared favorably with results found at the Kentucky (1) and Illinois (2) experiment stations.

Figure 3 shows the effect of stage of lactation on per cent protein. The protein percentage dropped perceptibly from the first to the second month of the lactation period for all the breeds tested. This was followed by an increase to the tenth month of lactation, except for a slight tenth-month drop for the Guernsey-Jersey tests.

The effect of season on per cent protein (Figure 4) showed a decline during the summer months for the Holstein and Guernsey-Jersey milk, but the Ayrshire protein content increased to its highest point in August, followed by a sharp decrease in the fall months.

The effect of stage of lactation on per cent solids-not-fat is shown in Figure 5. The S.N.F. percentage dropped from the first to the third month of lactation for all the breeds on test. This was followed by a gradual increase and a leveling off near the end of the lactation period except for an unusual rise at the sixth month of lactation for the Guernsey-Jerseys. As far as seasonal effect on the per cent S.N.F. (Figure 6), there was an irregular decrease from the January tests to a low point with the July tests. This was followed by an irregular increase to the end of the lactation period.

The total solids (S.N.F. + Fat) of the Ayrshire and Holstein milk followed the same pattern (Figure 7) as the solids-not-fat. The Guernsey-Jersey showed a greater increase in total solids (T.S.) content during the last five months of the lactation period than did the other two breeds. The highest total solids content of the milk was reached in the months of May and December for the Holstein and Guernsey-Jersey breeds (Figure 8). The Ayrshire milk had the highest T.S. content in May, followed by a decrease that leveled off the remainder of the year.

The Ayrshire breed had the highest average chloride percentage of the breeds on test (Table 1). The

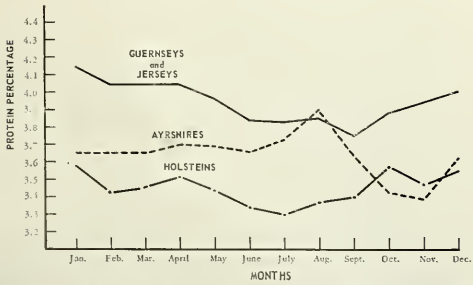


Figure 4. Effect of season on percentage of protein.

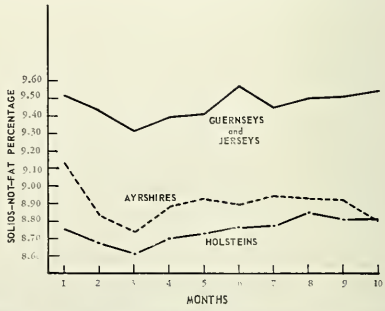


Figure 5. Effect of stage of lactation on percentage of solids-not-fat.

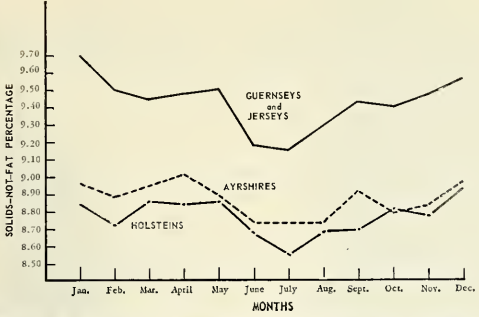


Figure 6. Effect of season on percentage of solids-not-fat.

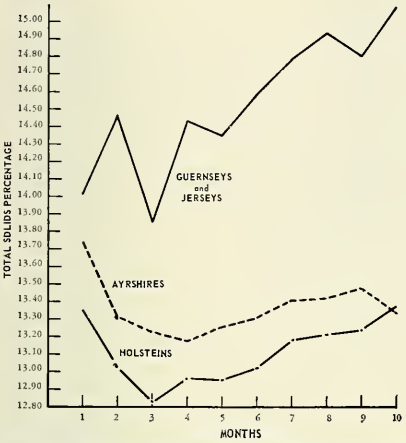


Figure 7. Effect of stage of lactation on percentage of total solids.

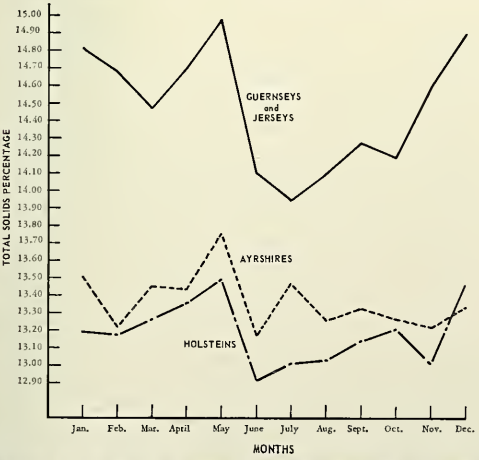


Figure 8. Effect of season on percentage of total solids.

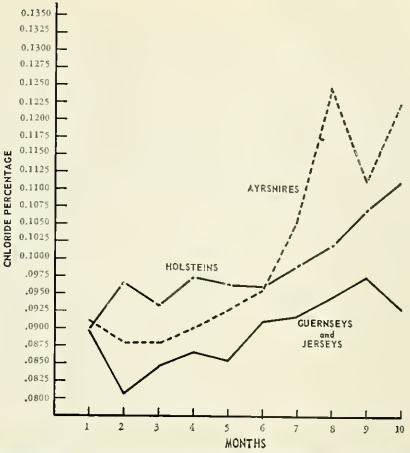


Figure 9. Effect of stage of lactotion on percentage of chloride.

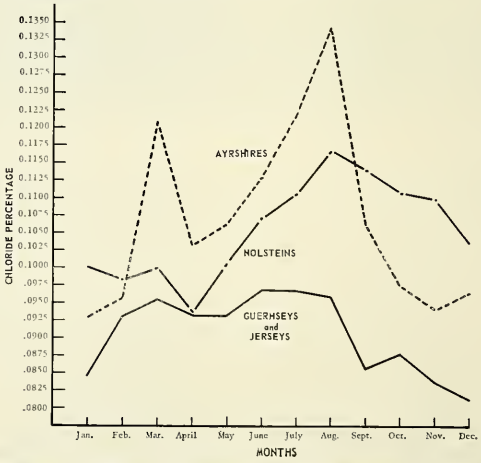


Figure 10. Effect of season on percentage of chloride.

Holstein percentages were slightly lower than the Ayrshire samples. The Guernsey-Jersey chloride tests were lower throughout the lactation period (Figure 9) than the other two breeds. The chloride percentage of nearly all of the samples was below 0.12 per cent, which is considered normal (3). Mastitis will cause the chloride percentage to rise, increasing proportionally to an extent dependent upon the severity of the infection.

The effect of seasonal pattern is shown in Figure 10. In general, the chloride percentage for all the breeds tested was highest during the summer months and lowest during the winter months.

The average freezing point of 783 samples of milk was −0.543°C, which is somewhat higher than the

(*Continued on Page* 15)

There

G. C.

Anderson is An
Henderlong is

LeRoy Stevens, in charge of Reedsville Experiment Farm, gazes over the meadow plots. Each of the meadow plots is combined with a hill bluegrass-white clover pasture to make a pasture-forage system of bluegrass, orchardgrass, fescue. (Photo by Jack Cawthon.)

DO you remember the stories of the Lost Dutchman Gold Mine? We have such a lost gold mine in West Virginia, but of a somewhat different nature—our lost mine is in the form of thousands of acres of neglected and forgotten grazing and hay land, much of it hill land.

The effective use of hill land requires knowledge and skill more demanding than that needed to properly use level or gently rolling lands; for that reason we do not know as much about the profitable use of hill grazing lands as we should. In order to develop a better understanding of such land, a pasture research project was established at the Reedsville Experiment Farm in Preston County. Part of a small valley was chosen for the experimental plots. The bordering hills have northeastern and southwestern exposures and the slopes range from 15 to 45 degrees. The valley floor is gently rolling and typical of much of West Virginia's meadow land.

The arrangement of pastures and meadows is shown in Figure 1. The hill areas were cleared, divided into 12 pastures of 1.4 acres each, limed, fertilized, and disced, and seeded to bluegrass and white clover. The meadow land area was divided into 12 sections of 2.1 acres each. Four of these were seeded to bluegrass to represent much of West Virginia's meadow hay lands. Four other sections were seeded to Potomac orchardgrass, because this grass is of major importance for hay production in the State. The remaining four sections were seeded to Kentucky 31 tall fescue because of its hardiness and resistance to heat and drought.

Each of the meadow plots is combined with a hill bluegrass-white clover pasture to make a pasture-forage system—bluegrass, orchardgrass, fescue.

At present, the most useful plants for hill pastures are bluegrass and white clover. When treated properly, these plants can produce large quantities of feed, but total production is limited by the growth characteristics of bluegrass and too often by low levels of soil fertility, a heritage of accumulated years of land abuse.

Although bluegrass has shortcomings as a pasture plant, it is the only grass available now which can persist under common grazing management. When temperatures are cool and moisture is abundant, this grass flourishes. But in summer heat and dryness it becomes dormant and is for all practical purposes unproductive until fall. Thus, pastures based on bluegrass can support grazing animals satisfactorily only during the spring and fall. In terms of animal needs, some other source of feed must be available during that part of the year when bluegrass is dormant. This includes the winter as well as the summer period when feed needs are considered for the whole year.

Since the hill bluegrass-white clover plots are common to each system, then the value of each system in terms of its ability to meet the total feed needs of cattle and sheep for an entire year will be determined by how well orchardgrass, bluegrass, or fescue make good the shortcomings of the hill pastures. Of particular importance will be the management of each system to emphasize maximum grazing season.

Management of the three systems will in general be as follows: Grazing of the hill pastures will begin

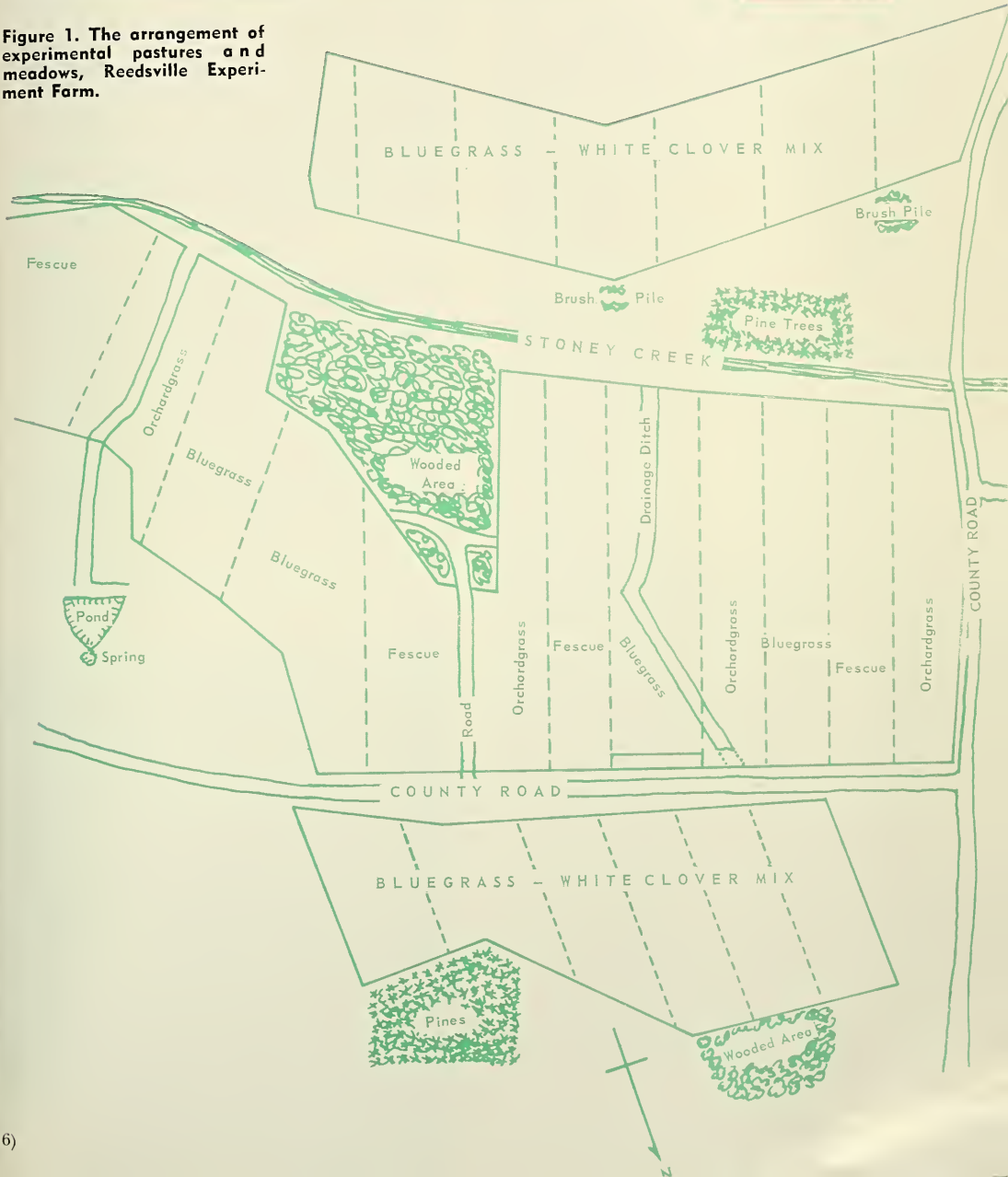
(Continu

Gold on the Hillsides

N, L. P. STEVENS, P. R. HENDERLONG, AND G. E. TOBEN

lman; Stevens is Asst. Horticulturist, and is in charge of Reedsville Experiment Farm; nist; and Toben is Agricultural Economist.

Figure 1. The arrangement of experimental pastures and meadows, Reedsville Experiment Farm.



Impact of Recreation on Natural Areas

ROBERT LEO SMITH
Asst. Wildlife Biologist

WE live in a time of rapid change. What was accepted as modern only a very few years ago is now obsolete and replaced by something newer. Our population growth and economic wealth have changed the landscape and our way of life. Urban and suburban sprawls are eating away at our open spaces; our water and atmosphere have become polluted. The nostalgic rural way of life under which most of us grew up is a thing of the past. Yet we, including the city bred, have not lost an awareness of some deep-seated urge that tugs us back to the outdoors. There is still something of the wilderness left in everyone.

This desire to return to the woods and fields expresses itself in the growth of outdoor recreation. When life was rural, woods and fields were close at hand; there was a daily contact with nature, and recreational needs were more often expressed in a desire to leave the woods and go to the town or city. Even if there was some temptation to go further afield, transportation was a problem.

Changes developed after World War I. Automobiles came into common use, highway systems were expanded, and city people went back to the country. Before 1910, for example, the number of annual visitors to all National Parks was about 50,000. By 1920 this number reached a million. Five years later it was two million; in 1928 three million. By 1958 it was 60 million and in 1965, 110 million.

The demand for outdoor recreation will continue to increase. If population continues its present growth, the number of people will double by the year 2000. This population is becoming increasingly concentrated in cities. Today 63 per cent of our people are urban, living on less than 10 per cent of the land. By the year 2000, this number will swell to 73 per cent (ORRRC, 1962). Shorter work weeks, longer vacations and more money are providing this concentration of people with the means and the time to escape the city. More cars and new and better highways are putting local recreation sites only minutes away and distant ones only a few hours or a day or so away. Travel is cheaper, and low income groups are finding it possible to visit more distant places. The population is younger; and young people participate in more activities and acquire more skills than their parents did. All this is having a tremendous impact on the economy, land use, and recreation sites. Public recreation areas are taking the greatest pressure; private areas are largely undeveloped.

Outdoor recreation may be a mass-use type of recreation concentrated on developed sites such as picnic areas and camp grounds; or it may be dispersed activity that takes place on large continuous areas with little or no facility developments such as hiking, back country camping, hunting, and the like. However it is viewed, outdoor recreation is based on land resource and as such it is bound to have some effect on the landscape.

That recreational use of land can cause site deterioration has been recognized for sometime. Lutz (1945), for example, observed that on areas of intensive use in picnic and camp grounds, pore volume and air capacity of the soil were decreased, while soil density was increased. More important, perhaps, soils in intensively used areas were only 1/20th as permeable as those on non-use areas. Recently Ripley (1963) found that as densities of tables on picnic areas increased, the depth of the upper A horizon of the soil decreased, understory vegetation died, and more water ran off than soaked into the soil, reducing soil moisture and increasing erosion.

Magill and Nord (1963) in their survey of 137 heavily used picnic and campsites in California pointed out that serious site deterioration was taking place. One-half of the areas were inadequately stocked with trees, and trees were abused by campers. Nails were hammered into them, wires were wrapped around them and bark was damaged by cars. Four-fifths of the areas were disturbed by trampling, erosion, and mechanical means. Two-thirds of them had a poor accumulation of protective plant litter on the soil. Removal of organic matter for fire prevention resulted in dust beds, reduced respiration and transpiration of plants, and inhibited the growth of trees.

The destruction of natural areas through overuse is not confined to camp grounds and picnic sites. It is also going on at an accelerated rate in the back country and the wilderness. Pack trails into wilderness areas have been cut ankle deep by horse traffic, turning them into eroding gullies (Snyder, 1966). On the Muir Trails in the High Sierra Wilderness some 70,000 people use a 50-mile stretch of trail every year. In the King Canyon National Park and the Sequoia National Park native vegetation of mountain meadows has been destroyed through overgrazing by pack horses. Uncon-

trolled hitching of horses wears away the soil around roots and creates a dusty, shabby non-wilderness look. Garbage piles are building up around the edges of wilderness campsites, while fireplace construction, bedbough cutting, and soil compaction are destroying the campsites (Hutchinson, 1962). In the Quetico-Superior Region, the canoeing wilderness, even lightly used campsites lost 50 to 99 per cent of their original ground vegetation. There was no reproduction of trees, saplings were cut or damaged, and erosion, soil compaction, and damage to roots of trees were serious (Frissel and Duncan, 1965).

The enjoyment of outdoors depends a good deal on the maintenance of natural areas. But the continuous deterioration and destruction of recreational areas is simply extending our self-made environmental problems of pollution, erosion, and crowding further into the countryside. Excessive deterioration is not necessary if we are willing to pay the costs of prevention.

Recreational Carrying Capacity

One way to approach the problem is ecological, involving the concept of carrying capacity. This concept, although rather poorly defined, is widely used in wildlife management. It involves the idea that an area can support only a limited number of animals and that any increase over this number cannot be sustained. An example of this is overpopulation of deer.

As with other terms, different shades of meaning are attached to carrying capacity. Carrying capacity has meant the number of animals the habitat actually holds, the upper limit of population growth, or the number of animals the habitat can maintain in a healthy vigorous condition.

Perhaps a better way of defining carrying capacity is to relate density to the environment (Dasmann, 1964). One concept is *subsistence density*, the upper level which a population can reach in a given environment. It is determined by the ability of the environment to produce sufficient food to support the population at bare survival level. This concept has little application to recreation, but two others do. They are *optimum density* and *tolerance density*. Population-wise, optimum density implies that the population has adequate food, water, and shelter to meet its needs. Tolerance density is saturation density. It is the level at which tolerance (or the lack of it) among animals of the same species permits no further increase.

Applied to recreational carrying capacity, optimum density would be that level of use at which the individual derived the greatest satisfaction. Optimum density, of course, would vary depending upon the type of recreational activity involved. Optimum density for picnicking would be much greater than that for wilderness camping. But in either case crowding is absent and interference with the natural biotic community would be minimal.

Tolerance density would be that level of use at which the individual still derived satisfaction from the activity, but found himself rather restricted in his movements and in close, constant association, passive or active, with fellow recreationists. The numbers involved would, without considerable management, cause damage to the biotic community.

Of the two, optimum density level would involve the greatest per unit expense to operate and the greatest expenditure on the part of the user. Tolerance density would be the most profitable economically and the least expense for the user. But the quality would be directly related to cost.

These concepts are rather deeply buried in Wagar's (1964) interpretation of carrying capacity. He suggests that "recreational carrying capacity is the level at which quality remains constant either at high or low level." Management objectives must set the level at which quality remains constant, just as levels are set by biologists in sound wildlife management. For the purpose of determining recreational carrying capacity Wagar suggests as the objective of managing wildlands, "the sustained production of the highest quality recreation that is possible at acceptable costs." These costs would be determined by what the public is willing to pay.

Just as carrying capacity in wildlife management means limiting the number of animals in a given area at a level consistent with the maintenance of the habitat, so the carrying capacity on recreational lands implies some restriction of use. This restriction would involve certain costs or sacrifices such as fewer visits per person, regulation of conduct and movement, acceptance of different kinds of recreational experience, expenditure of time and money to reach quality recreational lands, and even increased costs for products of land made scarce by removal of such lands from production to meet recreational needs.

The nostalgic rural way of life is almost a thing of the past. Yet some deep-seated urge tugs us back to the outdoors, in many instances creating both engineering and ecological problems...

The management of recreational lands, as the management of wildlife range, involves some basic approaches. One is the manipulation of vegetative cover. Another is the control of animal numbers and movements. The former is largely ecological. The latter in this situation is basically an engineering problem.

Since vegetation is adversely affected by overuse, the problem on recreational areas becomes one of protecting vegetation, managing for those plants that are resistant to abuse, and substituting new plants that will persist on heavily used areas. Protection of vegetation involves some engineering. People must be prevented from either reaching plant cover or trampling it. The planting and maintenance of shrub barriers lessens damage to trees and adjacent forest by confining movements of people. But at the same time, this forced concentration of activity increases damage to the picnic and camping sites proper (Ripley, 1962).

Picnic and campsites under a heavy canopy have thinner ground cover and incur greater damage to roots of trees than those under an open canopy (Ripley, 1962). Sites with a heavier understory receive less damage by trampling and fewer tree roots are exposed. Whether this is due to greater protection afforded by shrub and herbaceous cover or to restriction of movements imposed by dense ground vegetation is not known. Thinning this heavy crown opens up the canopy and the understory vegetation responds to increased light which may result in better protection of the area.

Certain types of vegetation stand up under heavier use than others. Wager (1964) has demonstrated experimentally that grass and woody vines resist trampling more than herbs. In order to maintain under actual conditions a sod cover that is heavy enough to withstand abuse on picnic sites, the canopy would have to be quite open. This would destroy the aesthetic value of the woods. Maintainence of sod cover through dry summers and in more arid regions of the country would require some form of irrigation. The ability of trailing woody vines to stand up under use may be related more to the effect they have on people than to their inherent ability to withstand damage. Vines are not the most pleasant cover to walk on and may be avoided by picnickers and campers.

A major problem is that of increasing the carrying capacity of recreational areas. There are two possible ways. One is to disperse the population, and expand the habitat. This would involve the development of roads in unused areas and the establishment of new campsites and picnic areas. In the end this may be self defeating for expanded habitats have a way of filling up to a toleration or even subsistence level, and the problem has reappeared. The other way is to improve the habitat, the recreational area we already have, so that it will support a denser population. In other words, we want to build the population up to tolerance level. This would work well in mass type recreation, but it would destroy the wilderness.

In wildlife management the tolerance level often is dictated by the social behavior of the animals. Fortunately this will also be true for humans, only more so since the camper and picnicker seem to be sort of gregarious fellows. We have labored long with the idea that all campers were eager to "get away from all," to rough it. This we have discovered is not true. The average suburban camper, by the appearance of campground inhabitants, wants to bring his city comforts with him to the woods, including television, easy chair, and the like. He is not particularly interested in a bird song or in the sound of the wind in the trees. It is not the outdoors so much that attracts the majority of visitors to state and federal campgrounds, but the desire to socialize and meet people in a relaxed atmosphere. The young people like their dance sessions in the evening and their folk singing around a campfire, adults enjoy their visits, and all want their swimming and sunbathing in the afternoon. Camping also is a cheaper way to travel, a means of avoiding high motel bills. The majority of visitors to public camp grounds are transients, stopping for a night or two and then moving on. For them remoteness is not necessary or even desirable, but such convenience as electricity, laundromats, and nearness to stores are important.

If this is true, and it appears to be, then why should we attempt to mix natural forest recreation in many places with fresh air camping? To do so is expensive and extremely hard on the natural environment. If the majority of the camping public is interested mainly in social activities, why force these people to camp out in the remote wooded areas? Perhaps the answer is as Gregerson (1965) suggested: the development of campurbias—wide, paved open spaces designed to provide as many campsites as possible on a given area, close to swimming, and similar activities. This would adequately take care of the dust and dirt problem and would permit better sanitation facilities and garbage collection, two problems which are acute in outdoor recreation areas. At the same time, we would be able to keep these people out of the woods and prevent irreparable damage to the biotic community.

There will of course be a considerable body of campers and picnickers to which this type of arrangement would not appeal, and their needs, too, must be met. Here we are face to face with the problem of controlling and handling the number of people, which is an engineering problem. A few approaches from campurbia might be utilized here. For example, asphalt pallet or gravel might be placed around tables, fireplaces and tent sites, since something needs to be done to eliminate the dust bowls that inevitably develop around picnic tables and tent sites.

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SPOT PLANT To Assure Better Timber Stands

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Figure 1. Yellow-poplar interplant 12 growing seasons after it was introduced into Stand 1. The surrounding saplings, primarily elms and oaks, are approximately the same height as the interplanted poplar.

ADEQUATE amounts of desirable seedlings or sprouts usually will be present to assure a new stand of high potential value following regeneration cuttings in mature hardwood stands. Occasionally, even with well-planned reproduction methods, insufficient amounts of desirable regeneration result to assure a future stand of high-quality merchantable trees.

One way to improve the amount, spacing, and composition of natural regeneration is to supplement natural seedlings with planting. This practice, long used in European forestry, is attracting increased interest in this country.

Spot planting in natural stands differs in many respects from the conventional tree planting operation on open ground. In spot planting no rigid, uniform spacing is followed. In addition, there is the challenge of selecting the best location for each seedling to assure its survival.

The terms "interplanting," "spot planting" and, occasionally, "reinforcement planting" are used to de-

Figure 2. (Below) Yellow-poplar interplants in Stand 2, seven growing seasons after planting. The surrounding natural tree seedlings, the same height as the poplar, include black cherry, white ash, and shingle oak. The slashings from the 1966 cleaning are evident. Dead boles of frilled cull trees stand above the new stand.

Figure 3. (Right) A mixture of yellow-poplar, shingle oak, white ash, and black cherry in Stand 2. The poplar seedlings were interplanted seven years ago, and they are growing as rapidly as the notural regeneration.

scribe the introduction of nursery-grown seedlings into young natural stands. European foresters appropriately describe these operations as "enrichment plantings." Regardless of the descriptive term, the intentions are the same. (Actually each term stresses a certain principle or benefit.)

During the past decade two interplantings were made at the West Virginia University Farm Woods in Monongalia County—each to correct deficiencies in young stands and to provide more information about such techniques and their place in Appalachian hardwood forestry.

Since the two plantings were made under different conditions, the results are described separately.

Stand 1

Prior to the harvest cutting, a mature mixed oak stand occupied the site. The overstory included white oak (*Quercus alba* L.), black oak (*Quercus velutina* Lam.), northern red oak (*Quercus rubra* L.), blackgum (*Nyssa sylvatica* Marsh.), red maple (*Acer rubrum* L.), slippery elm (*Ulmus rubra* Muhl.), and American beech (*Fagus grandifolia* Ehrh.). In the spring of 1953 the overstory of a one-acre stand was removed, and it was assumed that existing understory seedlings, plus additional new seedlings from seed on the forest floor, would form the nucleus of the new hardwood mixture.

In the summer of 1954 an adequate number of vigorous oak, elm, and red maple seedlings covered three-fourths of the stand, but scattered openings, up to 400 square feet in area, had no tree seedlings or sprouts, and these areas were dominated by shrubs, blackberry (*Rubus* spp.), and grape vines (*Vitis* spp.). It appeared that these spots would remain open resulting in permanent gaps in the stand.

In the spring of 1955, two years after the cutting, fifty 1-0 yellow-poplar (*Liriodendron tulipifera* L.) seedlings were interplanted in the stand. In determining the number of seedlings for each opening, the following plan was generally employed: 300-400 square foot openings received four seedlings; 100-300 square foot openings, three seedlings; 70-100 square foot openings, two seedlings.

Natural breaks in the existing vegetative cover were used to select the exact spot for each seedling. At the time of planting all brush and vines within a six-foot radius of the planted seedlings were removed.

The poplar seedlings were reexamined in 1956, but no cleaning was warranted at that time. In the fall of 1964 a uniform cleaning was made throughout the entire stand, releasing not only the interplants but the natural seedlings as well. The 30 planted poplar that had survived were the same height as the natural regeneration. Crown closure was taking place, producing an even crown canopy.

Figure 1 shows one of these interplants 12 years after it was introduced into Stand 1.

Stand 2

In the spring of 1956 this quarter-acre stand included young saplings of poorly-formed crab apple (*Malus coronaria* (L.) Mill.), hawthorn (*Crataegus* spp.), white ash (*Fraxinus americana* L.), blue beech (*Carpinus caroliniana* Walt.), flowering dogwood (*Cornus florida* L.), and hickory (*Carya* spp.). Although the stand was 20 years old, crown closure was not yet complete due to understocking. A dense growth of spicebush (*Lindera Benzoin* (L.) Blume) dominated the understory wherever there was adequate sunlight.

In April 1956 all woody growth less than five inches d.b.h. (diameter breast high) was cut from the plot and all stumps two inches in diameter and larger were treated with herbicide. The few trees larger than five inches d.b.h. were frilled and treated with herbicide. In May the plot was planted with 1-0 white ash using a six- by six-foot spacing.

Examination of the area in 1958 showed that the white ash seedlings had failed to grow, possibly because of damage to their taproots during lifting at the nursery. Spicebush sprouts, now four feet tall, were severely suppressing the white ash seedlings. The only promising seedlings scattered through the spicebush cover were shingle oak (*Quercus imbricaria* Michx.), white ash, and black cherry (*Prunus serotina* Ehrh.). Half of the stand area contained no desirable regeneration.

In the spring of 1959 fifty yellow-poplar seedlings were planted in natural openings in the spicebush cover. At the time of planting, all woody material and vines within a six-foot radius of the poplar were cut. In 1963 an additional cleaning was necessary around each interplant. In the fall of 1966 a second and final cleaning was made.

It was apparent at the time of the last cleaning that the 26 surviving interplants and the natural seedlings would be able to compete successfully with the spicebush in the future. Crown closure had not yet taken place.

Figures 2 and 3 show portions of this stand in January 1967, seven growing seasons after the interplanting.

Discussion

Observations indicate that the timing of the interplanting is extremely important. The sooner interplants are introduced after the cutting, the higher the survival and the less the need for cleaning. If seedlings are introduced into natural openings the year after cutting, the competing vegetation will not have attained sufficient height or vigor to interfere excessively with the interplants. Since it is usually possible to evaluate the abundance, vigor, and distribution of natural regeneration the year following the regeneration cutting, the need for interplanting can be determined early enough to assure success.

In spot planting it is particularly important that introduced seedlings commence height growth as soon as possible, so that their height increases as rapidly as that of the surrounding vegetation, thus alleviating the necessity of repeated cleanings. Only the largest and healthiest planting stock should be utilized for interplanting. Poplar seedlings with thick, fleshy terminal buds and large branching root systems not only give the highest per cent survival, but also exhibit rapid initial height growth. A simple method of grading yellow-poplar seedling stock is described in a recent issue of this publication.[1]

The question of how many seedlings to add when reinforcing existing regeneration is a controversial subject. Since interplantings are generally emergency operations, done at a direct cost and with no immediate financial returns, most commercial forest-land managers would agree to bring existing stocking up only to the minimum that will guarantee a successful crop. In hardwood types, young sapling stands of desirable species and quality with 200 well-spaced seedlings per acre should be adequately stocked to assure one intermediate cutting and a profitable final cut.

Thus, in a specific interplanting operation, if half of a one-acre area is non-stocked, then a minimum of 100 new seedlings would be needed, if they should all survive. Experience with the two interplantings indicates that approximately half of the interplants survived the planting operation and the competition during the period of slow initial height growth. Thus, twice the number of required stems should be spotted throughout the non-stocked portion to assure the survival of 100 trees.

Where competition from surrounding vegetation is not severe, possibly fewer than twice the number of desired trees could be planted, since seedling mortality would be less. On the other hand, where severe competition is expected, more than twice the number of desired seedlings should be planted, and the developing stand should be examined annually for several years to determine the need for cleaning. In general, competition with interplanted seedlings is on the more fertile sites, since competing vegetation grows rapidly and natural openings close quickly on these sites.

Care must be exercised to choose a species for interplanting that exhibits rapid initial height growth, and one that is somewhat tolerant of shade. Yellow-poplar has these advantages when planted on average or better sites. Among the native pines, white pine (*Pinus strobus* L.) would survive in interplantings more readily than red pine (*Pinus resinosa* Ait.), pitch pine (*Pinus rigida rigida* Mill.), or Virginia pine (*Pinus virginiana* Mill.), since these latter three species are extremely intolerant and respond slowly to release after suppression.

[1]Carvell, K. L. 1966. Combat herbaceous competition with the use of large yellow-poplar planting stock. *Science Serves Your Farm and Home*, January 1966. pp. 3-4, 16.

EFFECTS OF BREED. . .

(*Continued from Page 7*)

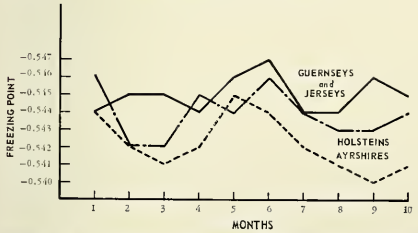

Figure 11. Effect of stage of lactation on freezing point.

officially accepted standard of −0.550°C (4). This higher freezing point was probably due to the samples being stored frozen (5) before the freezing points were determined.

The stage of lactation had little effect on the freezing point (Figure 11). The difference between the high and low readings was only 0.007°C including all breeds. The freezing point tended to be higher during the middle one-third of the lactation period.

The effect of season on freezing point showed no definite seasonal pattern (Figure 12). No explanation

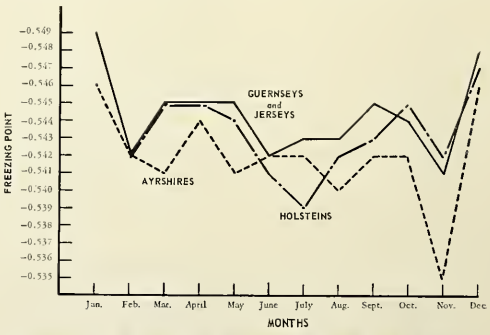

Figure 12. Effect of season on freezing point.

can be given for the sharp rise in the November Ayrshire samples.

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IMPACT OF RECREATION. . .

(*Continued from Page* 12)

To protect the natural environment, the movement of people needs to be controlled. The first step is to zone the area into parts that people will occupy and into parts they will look at. This would have to be based both on ecological and man-based criteria followed by planning to control the movements of people. Well defined paths need to be established with built-in inducements to keep people off tree roots and out of the shrubbery. This can be done by the strategically planted thorny shrubs, and building rock and log barriers. Carefully planned parking lots would keep cars out of many areas and force people to move on foot. Thus good planning could channel the movements of people, reduce the damage they do, as well as provide durable surfaces.

Controlling the movements of people on an area is one thing, keeping the number down to a predetermined density level is another. One way of controlling the number is to allow no more on the area than picnic sites and campsites will handle. This is not practiced in many places now. Another way of controlling carrying capacity is to set a charge to cover management costs of the area. For a private area this is the bread and butter. But if free public campgrounds are nearby, the private developer is at a real disadvantage. The time is coming when public areas will need to charge a fee simply to cover the cost of sanitation and garbage disposal. Another method is limitation of use. If one wishes to travel far off the trail, a permit would be needed. Wilderness areas might be restricted to hiking and horses would be barred. In this way numbers at any one time or at any one season could be controlled.

A certain amount of artificiality may also have to be introduced just to save the wilderness from people. Wilderness trails need to be planned with as much thought as a highway. Wilderness campsites need some sort of unobtrusive sanitation facilities to prevent pollution and aesethic deterioration of the site. Garbage disposal is another problem. If full food cans are packed in, then empty cans should be packed out. Controlling movement and dispersion of users in the wilderness also is critical. Campsites need to be strategically located to disperse both people and horses and make more even use of available range. Rotation of campsites is another solution. When camping areas show first signs of deterioration they should be closed and the campers directed to other sites until the first areas have recovered. This in itself would impose limitation on the number of users.

Recreation problems in natural areas are immense and bound to grow. We must think in terms of carrying capacity of given sites. Once the carrying capacity is determined, it then becomes an ecological and engineering problem to plan and supervise the distribution of people and the establishment of durable areas that will withstand heavy use and prevent the deterioration and degradation of the surrounding biotic community. The need is imperative.

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THERE'S GOLD. . .

(*Continued from Page* 9)

in late April or early May and continue until July. Forage on the meadow land areas will be harvested in late May. Regrowth on these areas is expected to be sufficient by July so that they can be grazed until about September, the period during which little plant growth on the hill pastures can be expected. Each meadow area will be divided in half with an electric fence so each part can be grazed alternately or so that herbage in excess of needs can be harvested. In September, grazing of the hill pastures will begin again and continue as long as sufficient forage is available. When these pastures are no longer capable of supplying a satisfactory amount of feed, grazing on the meadow lands will follow and be continued as long as possible in keeping with the amount of feed available, the maintenance of stands, and weather conditions. When grazing is no longer possible, the hay harvested from the meadow areas will be fed.

Each hill pasture and meadow land area will be limed and fertilized so that shortage of any of the major plant nutrients will not effect the productivity of any system. In addition, each meadow area will receive 150 pounds of nitrogen per acre in three applications—one application will be in March, a second immediately after the first cutting for hay, and the third at the end of the first grazing period.

In the beginning, yearling steers will be used. Later trials will use cows and calves alone or with ewes and lambs. The merit of each system will be determined finally by its ability to produce income in terms of beef, calves, lambs and wool—marketable animal protein.

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